LA-UR-79-2648

MASTER

TITLE: STATUS OF RADIOGRAPHIC STUDY, DEVELOPMENT, AND NEW APPLICATIONS IN THE LASL NONDESTRUCTIVE TESTING GROUP

AUTHOR(S): Lawrence E. Bryant, Jr., M-1

SUBMITTED TO: 22nd WANTO Meeting, Oak Ridge, Y-12 October 9 - 11, 1979

University of California

LOS ALAMOS SCIENTIFIC LABORATORY
Post Office Box 1663 Los Alamos, New Mexico 87545
An Affirmative Action/Equal Opportunity Employer

Form No. 836 R3
St. No. 2629
12/78

UNITED STATES
DEPARTMENT OF ENERGY
CONTRACT W-7405-ENG. 36

Status of Radiographic Study, Development and New Applications in the LASL Nondestructive Testing Group

Radiographic efforts are presently underway in Group M-1 in the following areas.

Study

1. Replacement of betatron with a Racetrack Microtron.

Development

1. Tomography.

2. Cineradiography.

3. Flash x ray.

New Applications

1. Flash x ray.

Replacement of Betatron with a Racetrack Microtron

Our betatron is now 27 years old and continues to give exceptionally high quality radiographs. It does require rather large amounts of nursing and we are fortunate to have Dana Elliott to perform this service. In addition to the high level of maintenance required, the betatron cannot meet some of the other needs we have. It would be very desirable to have a high energy radiographic facility that, in addition to precision radiography, could be called upon to perform neutron radiography, photon activation, and cineradiography.

As mentioned in the last WANTO meeting, candidates for this x-ray generator include an undefined product of LASL's Accelerator Technology (AT) Division and a Racetrack Microtron, possibly from Scanditronix of Stockholm, Sweden.

Our principal problem at the moment is funding for a design study by either AT Division for (essentially a new machine) or by Scanditronix for a modification of their basically medical microtron. This decision is complicated by general funding problems and a pending decision on a high-energy radiography facility for exclusive, or primary, use to x-ray Nevada devices.

In any event, radiographic parameters that are being considered include 30- to 50-MeV energy, up to 13,000 rad/min intensity, 0.5- to 2.0-mm focal spot size, and an electron beam emerging through a vacuum window onto a replaceable target.

Tomographic Development

A tomographic fixture has been built as shown in Fig. 1. One of the first applications of this system has been to radiograph at 200-kV reactor cooling water tubes with the imaging on Type M film. The basic goal was to demonstrate the feasibility of visualizing radial cracks caused by stress corrosion in the cooling tubes by computed tomographic reconstruction. The tomographic results will in turn be used by the Battelle Northwest Laboratory to calibrate an eddy current inspection for the tubing. The tubing has an o.d. of 22 mm and a wall thickness of 1.2 mm and the cracks are believed to be radial.

In general, radiography or radiation transmission gauges are not the inspection of choice when tight cracks are to be detected because the sensitivity of any radiographic technique to cracks is a very sensitive function of crack orientation. In fact this reasoning is implicit in the choice of eddy currents as the primary inspection technique for stress corrosion cracks. However, quantitative sizing of defects is very difficult if not impossible with eddy currents if good standards are not available. Tomography, while basically a radiation gauging technique and hence relatively insensitive to cracks, does yield a result that sizes defects to within the accuracy implied by the sampling theorem.

Because the features to be visualized are very small (<0.1 mm x 1 mm) with high x-ray absorbtion contrast, industrial x-ray film was chosen as the detector. While the film has relatively low-dynamic range, it has excellent spatial resolution comparable to a collimated detector.

After each exposure, the tube was rotated 1^{o} and the film advanced. Because the exposure slit plates were relatively thin, the background radiation started building up, which limited each film to 20 exposures. To permit the fan-beam geometry to be corrected to the normal parallel beam geometry, views were taken from -10 to 190^{o}.

After the films were developed, each slit image was scanned with a microdensitometer. The digital data resulting from each scan was stored on magnetic tape prior to manipulation in the computer.

Future experiments will use a collimated solid state detector in lieu of film.

This work has demonstrated the feasibility of visualizing actual stress corrosion cracks within reactor cooling tubes by tomographic reconstruction. There has been no determination of the spatial resolution of the technique nor exploration of the functional dependence of spatial resolution with such system parameters as:

1. scanning aperture size,
2. detector resolution (solid state and film),
3. signal-to-noise ratio, and
4. x-ray energy.

The results indicate that tomography may become an important NDE tool when properly developed. The next obvious step to take is to section the pipe in the vicinity of the tomographic section and compare the visual indications with the tomographic indications. At the same time a series of experiments using mockup and real cracks should be devised to explore the sensitivity of the technique to defect detection.[1]

Cineradiographic Development

LASL entered into a contract with the University of Dayton Research Institute on October 1, 1978 to provide funds for their development of a high speed cineradiographic system. (Which for our purposes is analogous with multipulse and multiple imaging, flash x-ray.) The system components as they are presently defined are as follows.

X-Ray Source - A cluster tubehead which takes up to up to nine channels of Hewlett Packard flash x-ray equipment - any combination of 150-kV and 300-kV channels in a 3 x 3 array with a center-to-center spacing of 4.5 cm.

1. Morris, P. A.; Kruger, R. P.; Wecksung, G. W. "Tomographic Visualization of Stress Corrosion Cracks in Tubing." LA-7891-MS Informal Report. (June 1979).

X-Ray-to-Light		
Conversion Screen	-	Gd_2O_2
Camera	-	Discrete sequential picture tube with an S20 photocathode deposited on a 40-mm diam microchannel plate. Output fluorescent screen is a P-20 on a 15 cm-diam fiber optic. The tube has magnetic deflection and focusing with electrostatic acceleration up to 30 kV. There will be 9 frames, 30 x 30 mm, 15 to 20 LP/mm resolution at a frame rate of 200,000/sec.

An artist conception of the camera is shown in Fig. 2. We have had numerous difficulties with this contract as we have gone through three different x-ray generators and the associated specifying of requirements evaluation of vendor bids, financial ups and downs, new vendors appearing and disappearing to name a few of the problems. The situation with the camera has been even more difficult and the outcome even less certain. We are still hoping for a working system by the end of 197[illegible]. But even if the present situation is messy and the proposed system never functions, I think we have begun a search that will continue for a longtime as the payoff of multiple, high speed, x-ray imaging is so enticing.

Flash X-Ray Development

These developments are mainly the acquiring of additional Hewlett Packard systems to meet the still growing demand for these services.

Energy Level	Systems Acquired Since the Last WANTO Meeting	Current Tally of Systems	Systems Being Acquired or Sought
150 kV	2	2	2
180 kV	---	4	---
300 kV	---	2	1
450 kV	2	2	---
600 kV	1	4	---
1 MeV	---	1	---
2 MeV	---	1	1
	5	16	4

New Applications of Flash X Ray

We had continued to work with Hercules, Inc. in Magna, UT and the Naval Weapons Center, China Lake, California on Navy funded application of flash x-ray to rocket motor experiments and more basic propellant studies.

Some examples of these are as follows.

Fig. 3 - 150-kV flash x-ray setup for shotgun launched propellant impact studies.

Fig. 4 - shotgun impact/flash x-ray typical results.

Fig. 5 - 480-kV flash x-ray setup for deflagration to detonation transition (DDT) experiment.

Fig. 6 - Static and dynamic radiographs of DDT experiment.

Fig. 7 - 2-MeV flash x-ray of second stage Trident missile motor in static firing at Tekoi, Utah.

In addition to these applications, we began working with Purdue University this July on a NRC funded, flash x-ray of mercury droplets in a shock tube - a reactor safety-related experiment.

We began working with Thiokol near Brigham City, Utah in August on a hot shock tube/flash x-ray experiment.

We have several other applications under consideration including flash x-ray at a gun range of Delco GM in Santa Barbara, California, other projects at Purdue University, China Lake and Hercules, Inc. Magna, Utah.

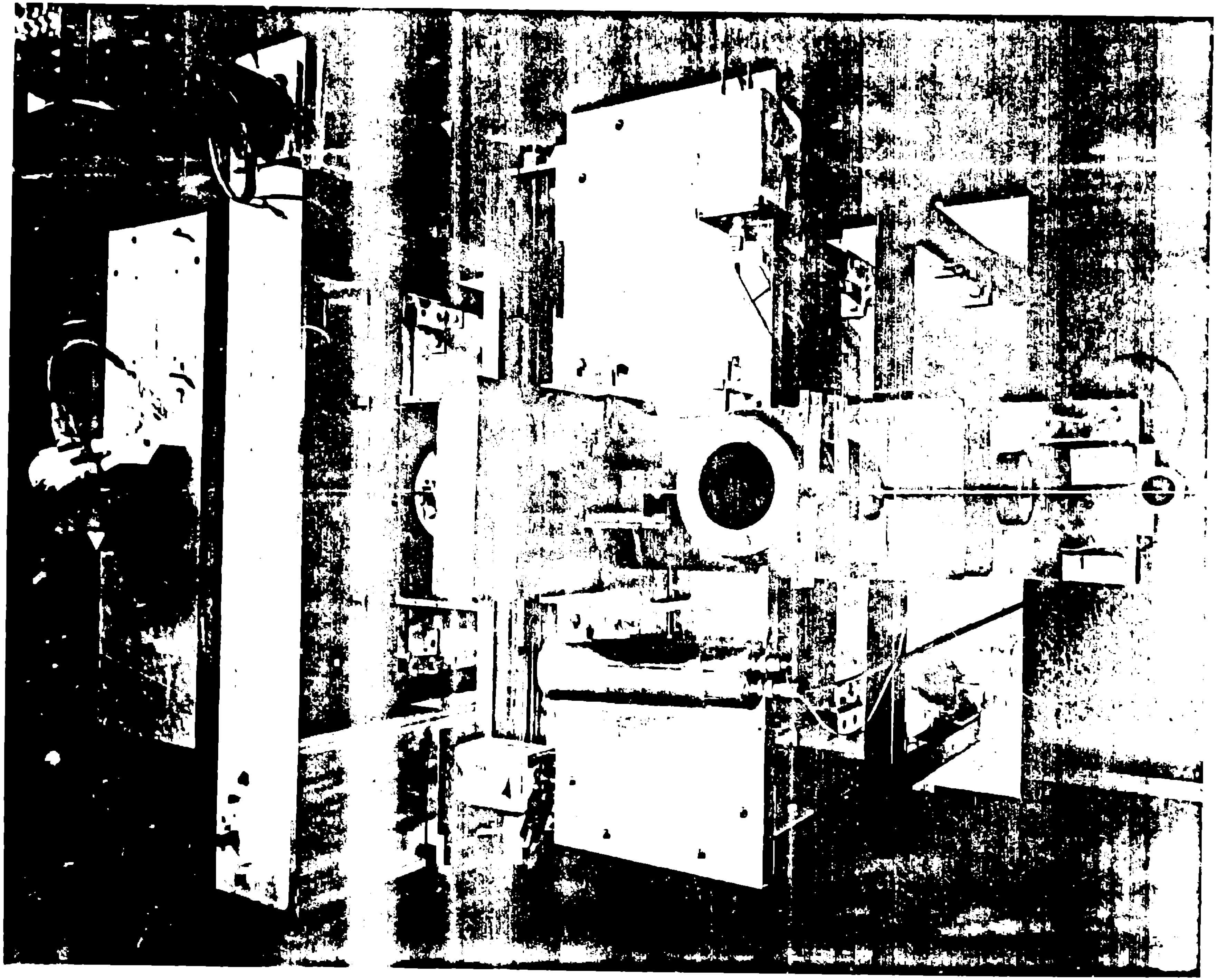


Fig. 1

BLANK PAGE

CINERADIOGRAPHIC CAMERA

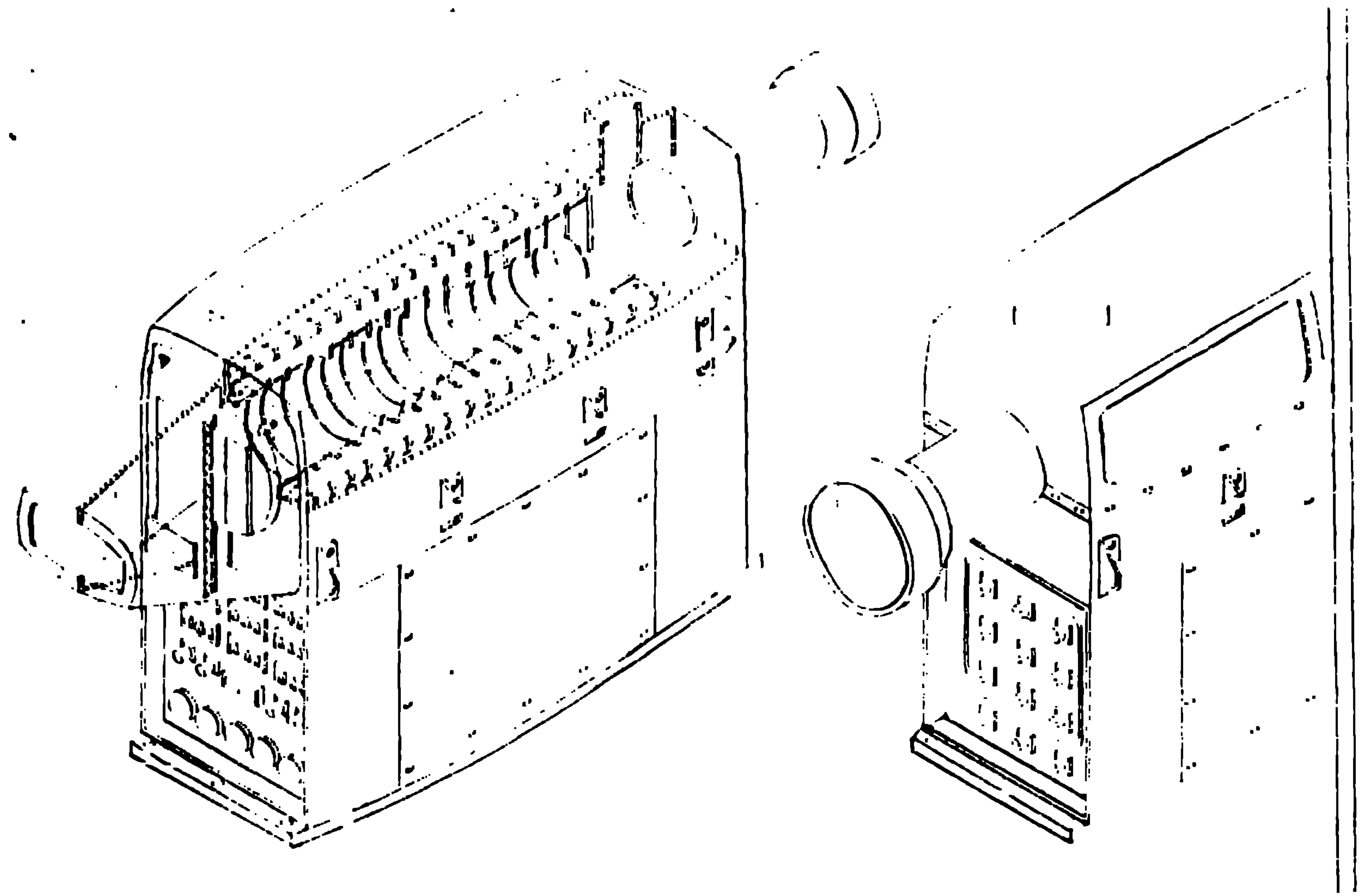


Fig. 2

SHOTGUN FIRING AREA

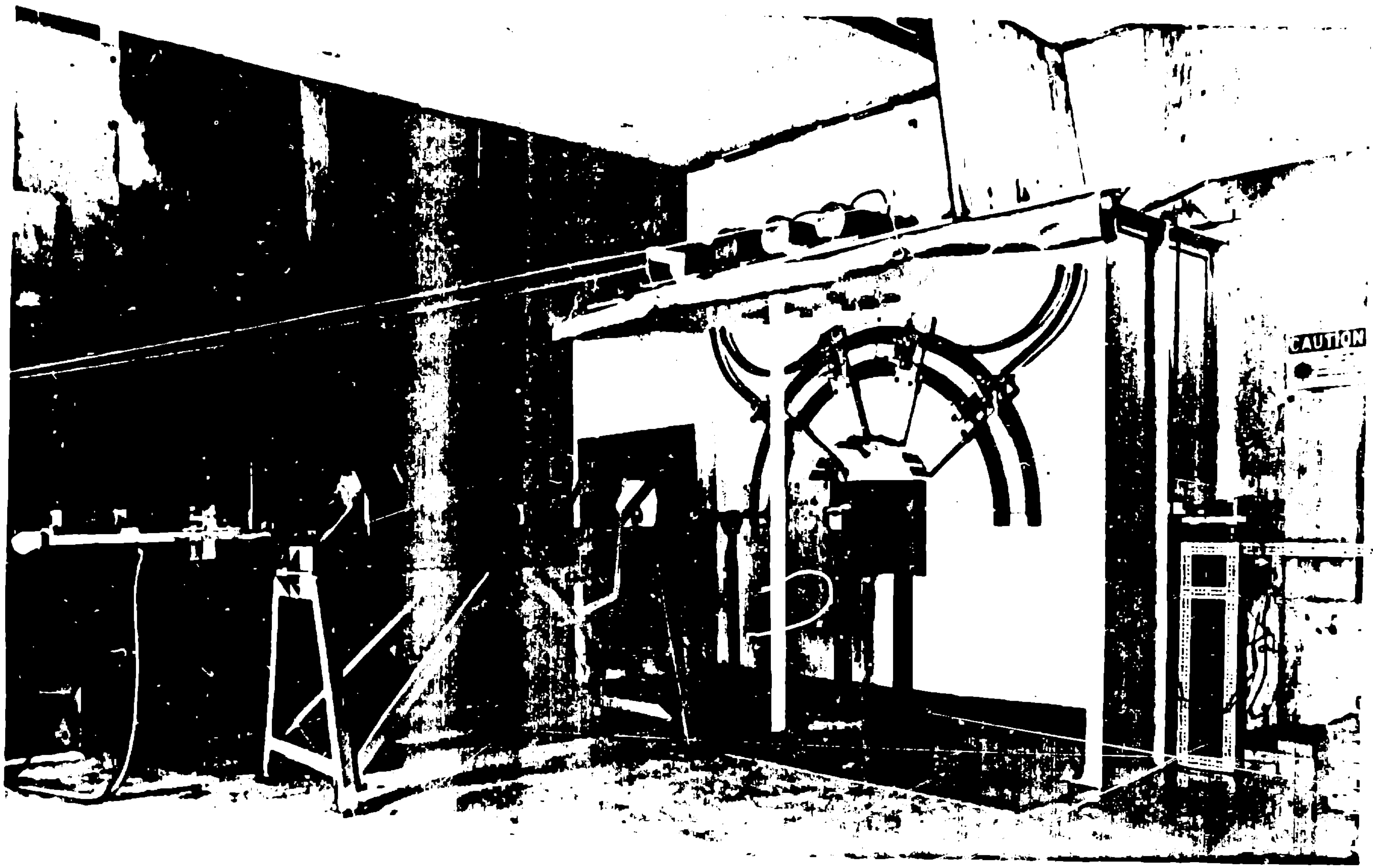
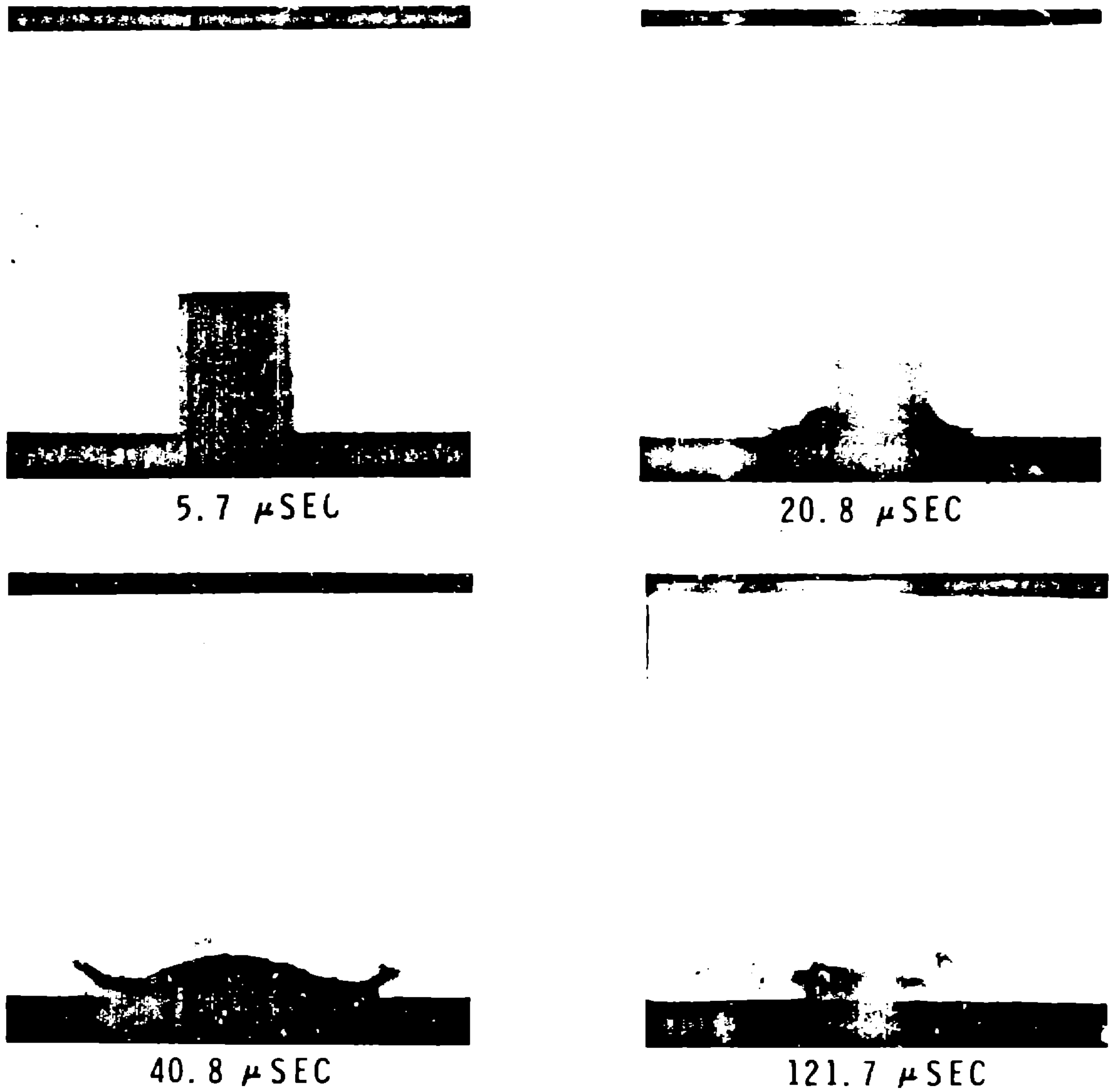


FIG. 3

SHOT GUN IMPACT TESTS

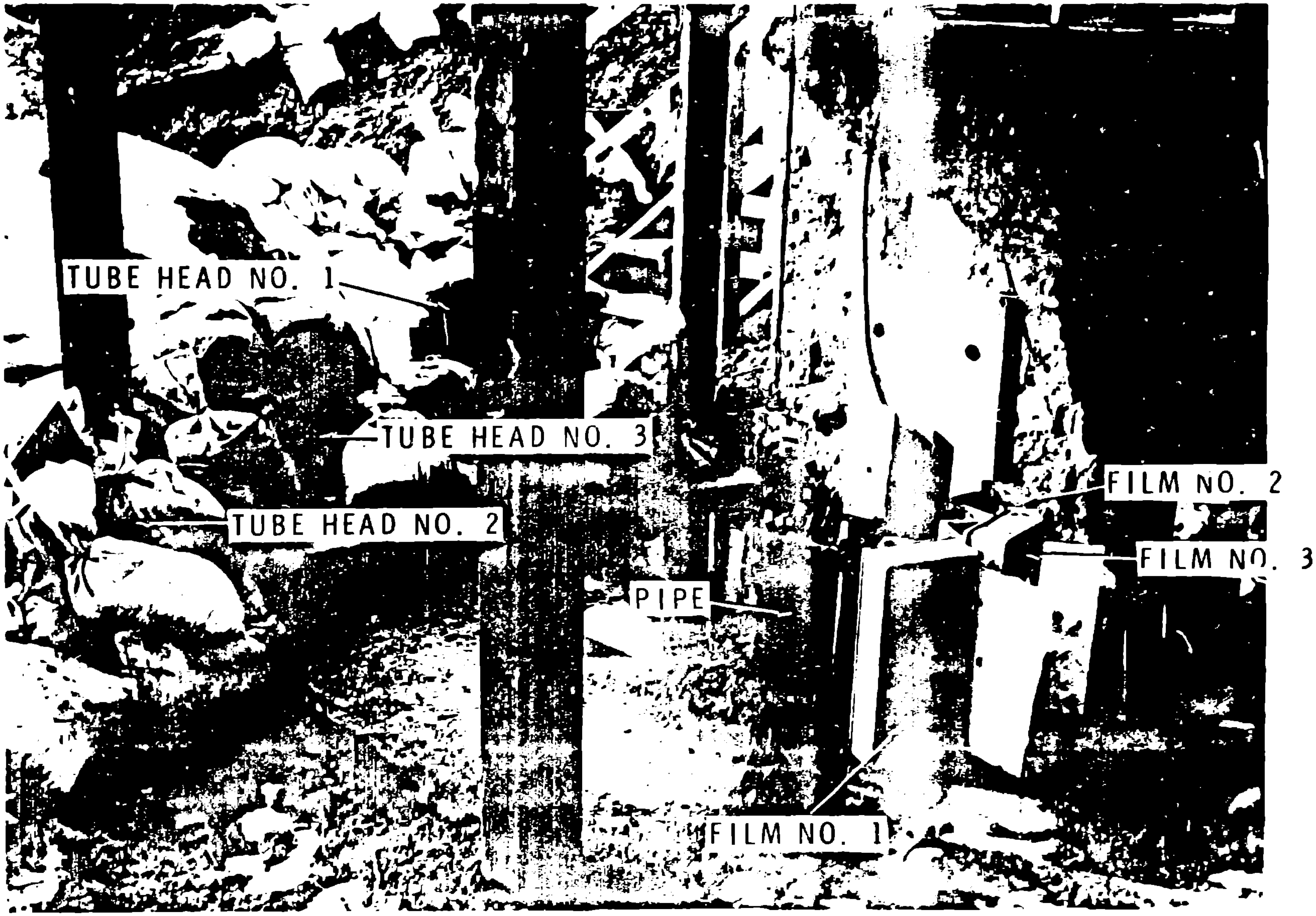
DEFLAGRATION RADIOGRAPH



IMPACT VELOCITY 1527 FT/SEC

Fig. 4

TRANSPARENT PIPE DETONATION TESTS
TEST ARRANGEMENT



TRANSPARENT PIPE DETONATION TESTS

EXPOSURE 92 μs AFTER IGNITION

EXPOSURE BEFORE IGNITION

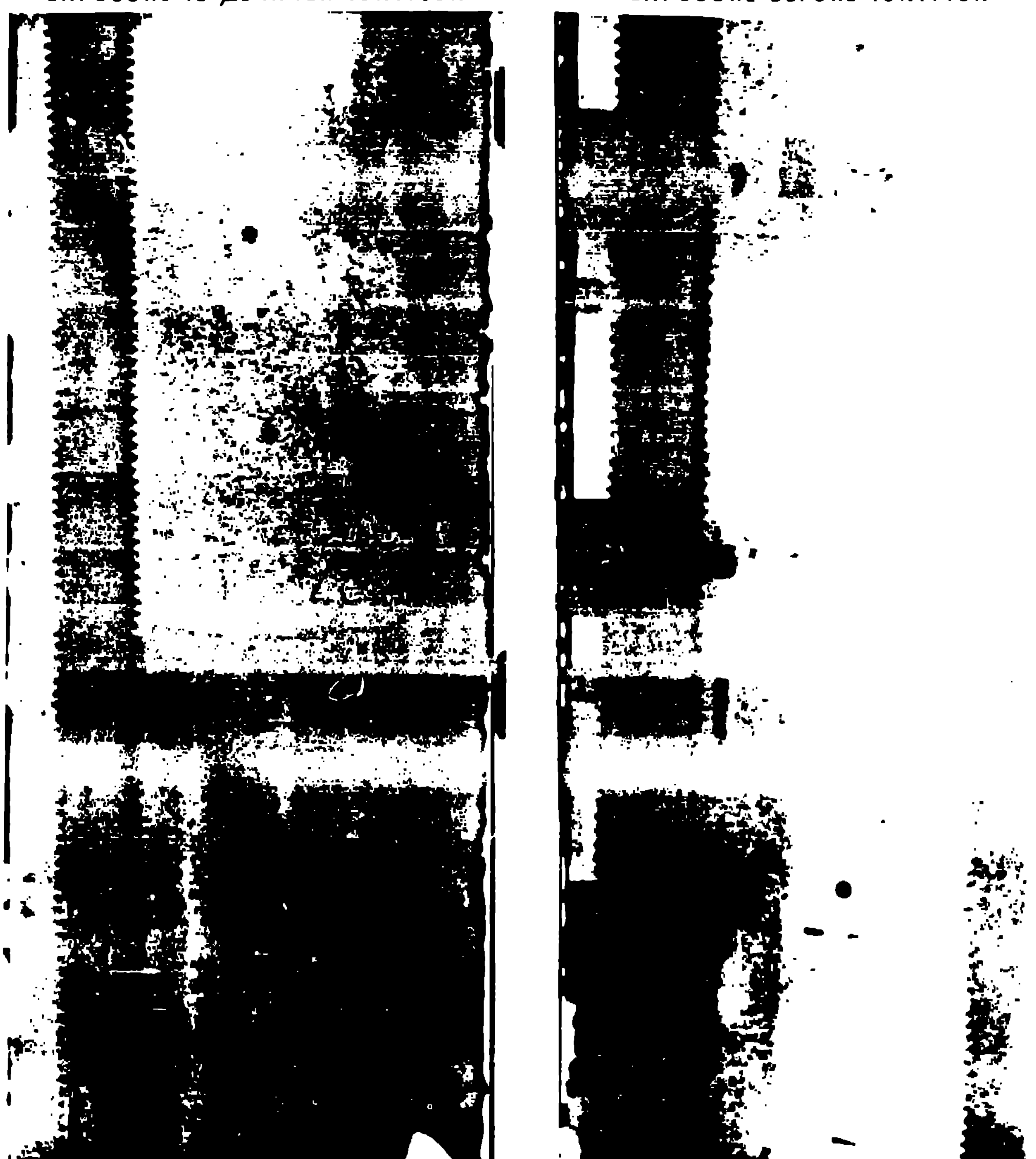


Fig. 6

BLANK PAGE

SX-66 NOZZLE UP FIRING TEKOI TEST RANGE

BLANK PAGE